Flubber experiment: measuring ^{17}F Coulomb breakup

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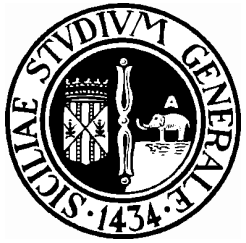


Outline

- Introduction on Coulomb breakup
- Interest of ^{17}F
- Experimental setup
- Preliminary theoretical analysis
- Summary

Breakup and capture

Stars powered by radiative-capture reactions
e.g. ^{7}Be(p,γ)^{8}B

Reactions take place at low energy
$\Rightarrow$ difficult to measure directly

Coulomb breakup $\approx$ inverse of radiative capture
e.g. $^{8}\mathrm{B} + \mathrm{Pb} \rightarrow {}^{7}\mathrm{Be} + \mathrm{p} + \mathrm{Pb}$

$\Rightarrow$ Idea: measure σ_{bu} to extract $\sigma_{\mathrm{capture}}$

This works only if:
1. Nuclear interaction negligible
2. Only dipole term plays a role
3. First-order of perturbation theory is sufficient

Does not seem fully valid for Coulomb breakup of ^{8}B
[G. Goldstein, P. Capel, and D. Baye, PRC 76, 024608 (2007)]

^{17}F vs ^{8}B

But ^{8}B ill-suited to test Coulomb-breakup technique:

- large discrepancies in direct measurements
- complex ^{8}B structure (^{7}Be not spherical,...)

On the contrary, ^{17}F is the ideal test case:

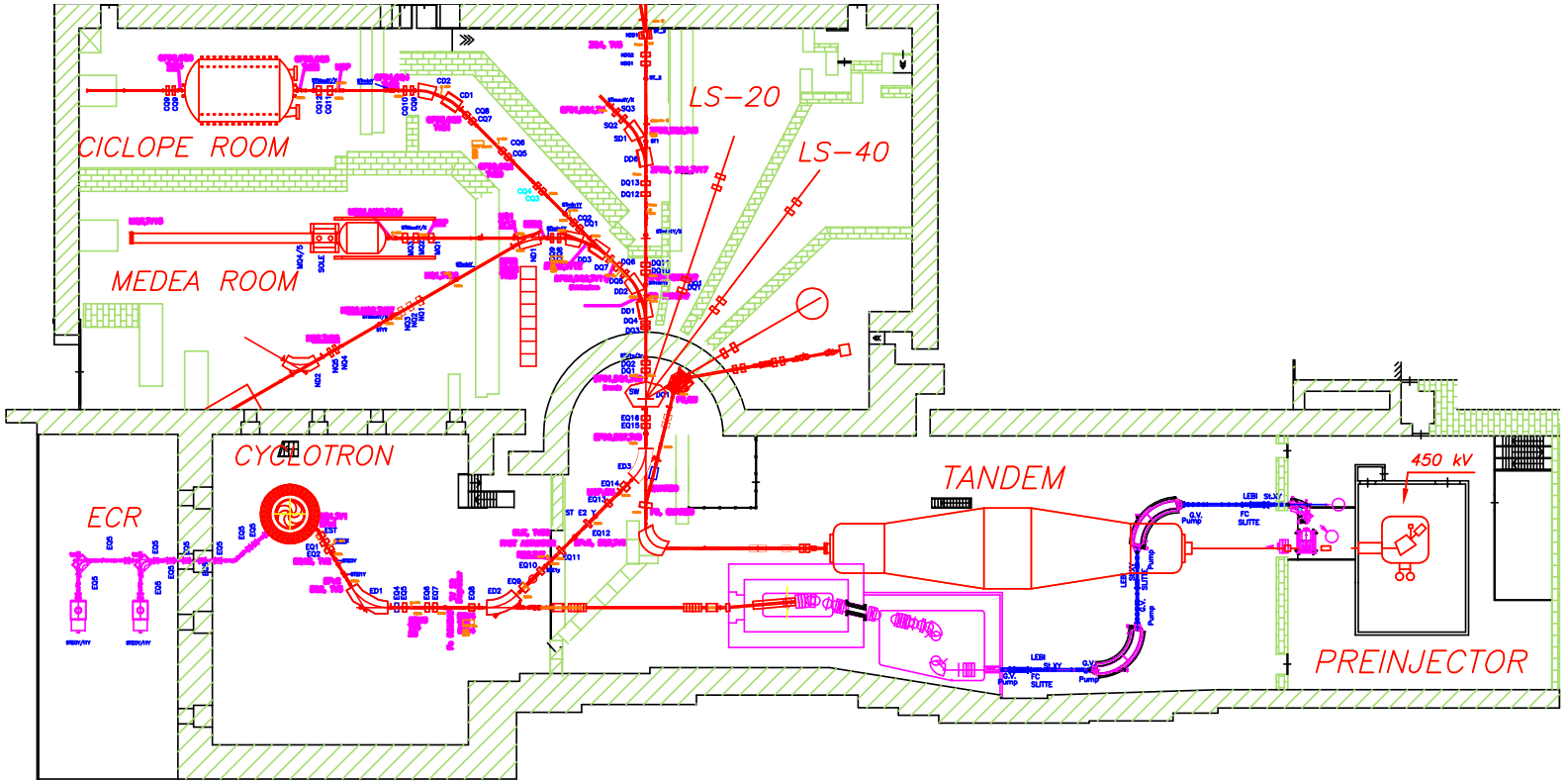
- reliable direct data for ^{16}O(p,γ)^{17}F at low energy
  [R. Morlock *et al.* PRL 79, 3837 (1997)]
- ^{17}F well described as p outside doubly-magic ^{16}O
  [J.-M. Sparenberg *et al.* PRC 61, 054610 (2000)]
- no resonance at low energy in ^{17}F spectrum

$\Rightarrow$ We propose to measure $^{17}\mathrm{F} + \mathrm{Pb} \rightarrow {}^{16}\mathrm{O} + \mathrm{p} + \mathrm{Pb}$
analyse it with our breakup model(s) (DEA, CCE,...)
compare the extracted $\sigma_{\mathrm{capture}}$ to direct measurements

Flubber experiment

Measure ^{17}F breakup on C and Pb at LNS (Catania)

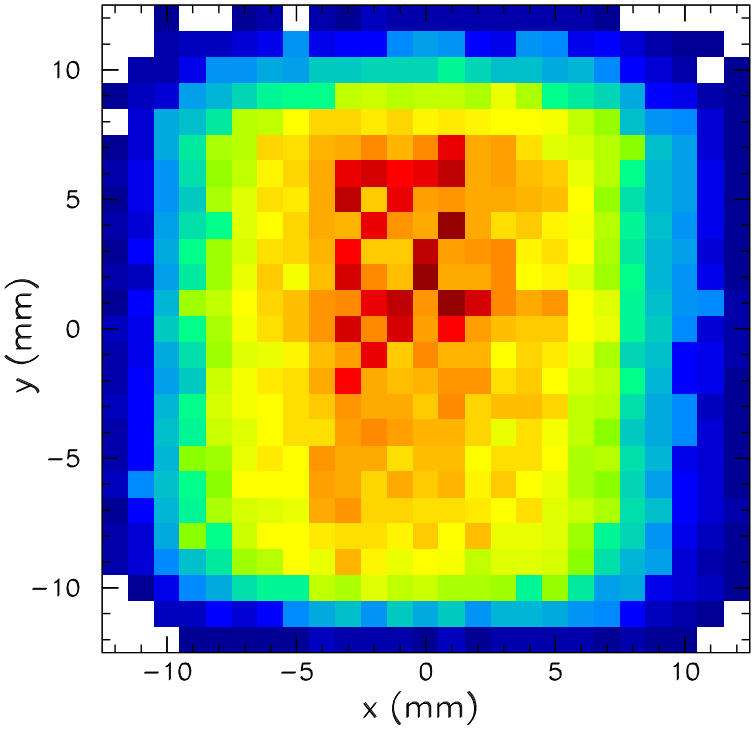
- ^{17}F produced by ^{20}Ne primary beam fragmentation at $45A$MeV on Be target
- After separation we get 3 10^3 pps ^{17}F at $40A$MeV

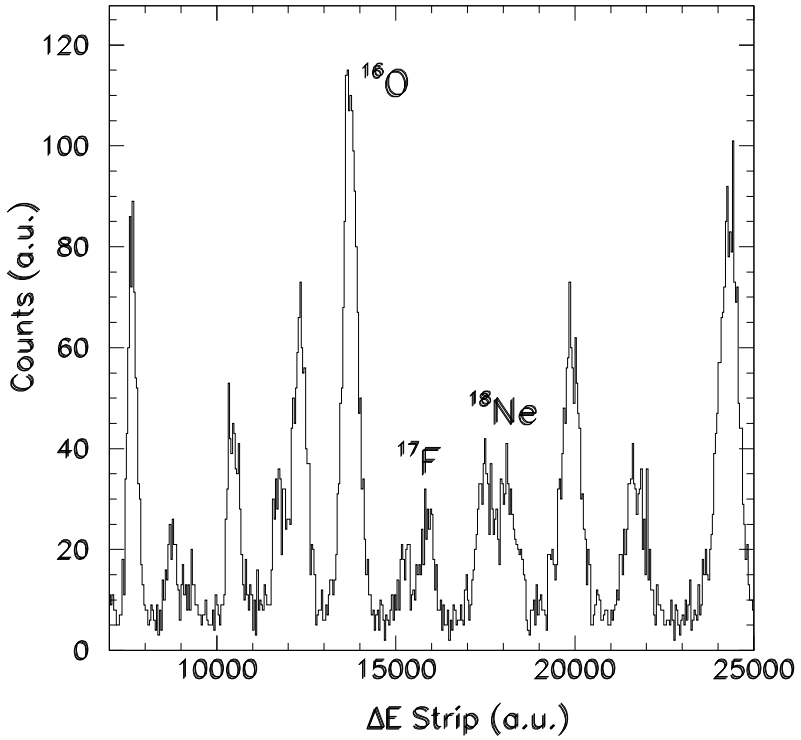


Projectile tagging

We use a double-sided Si stripped detector (24×24, 300 μm) to identify the projectile event by event in

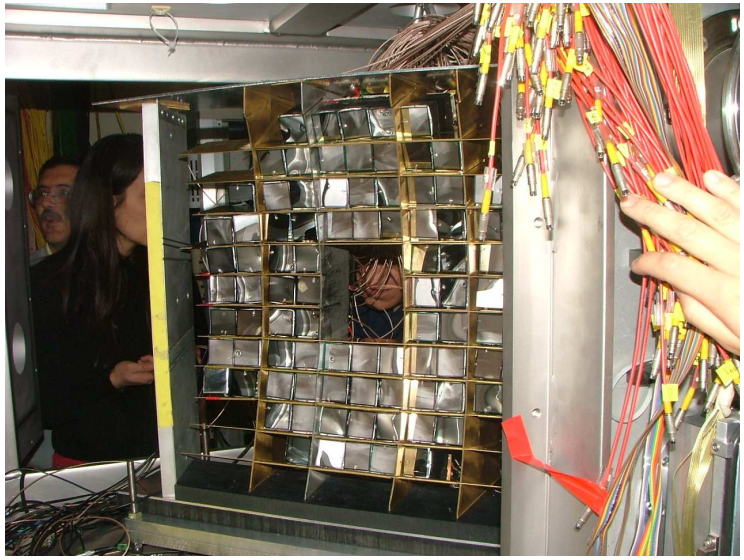
- Charge and mass (Z, A) by (ΔE, ToF)
- Position (x, y)



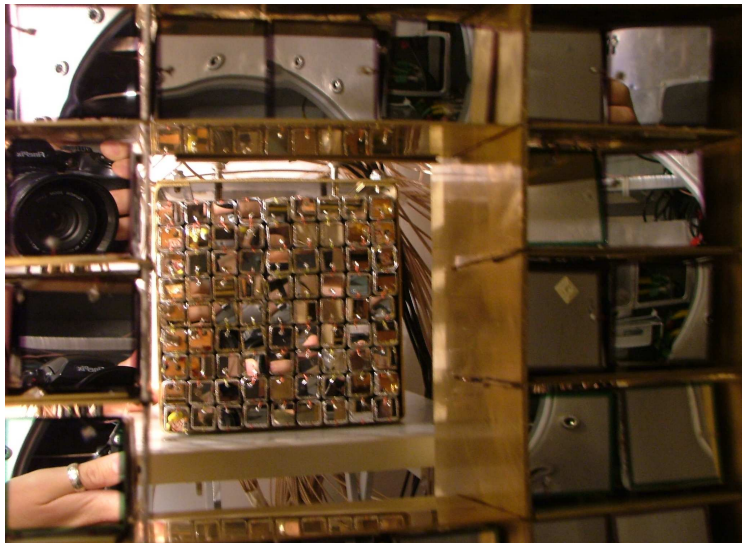


Detection setup

Two hodoscopes 80 cm behind secondary target

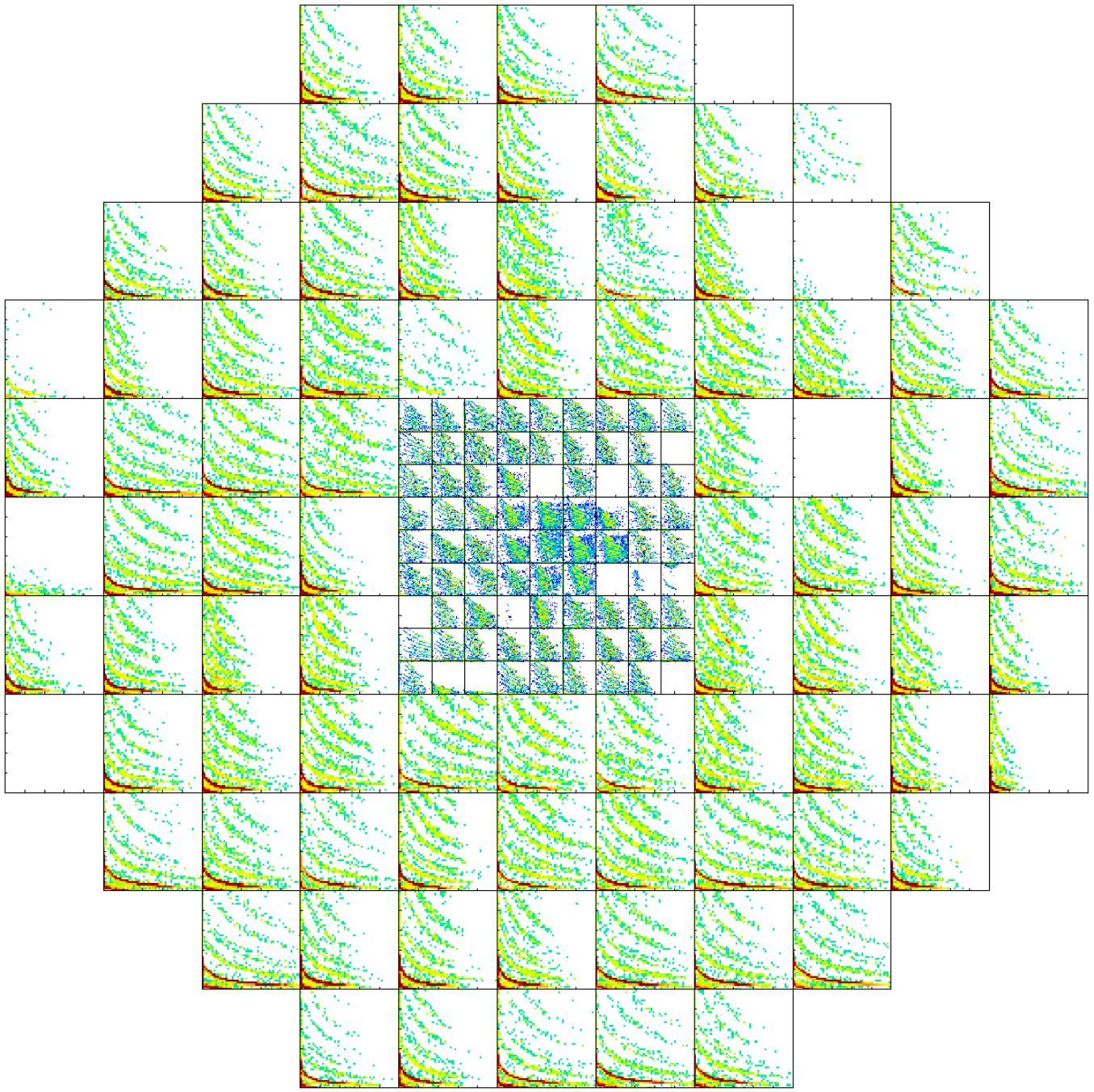


- Big hodoscope
  large angles (up to 21°)
  Detects p
  88 ΔE-E telescopes
  3×3 cm^2
  Si (50+300 μm), CsI (6 cm)



- Small hodoscope
  forward angles (0°–5°)
  Detects ^{16}O
  81 ΔE-E telescopes
  1×1 cm^2
  Si (300 μm), CsI (10 cm)

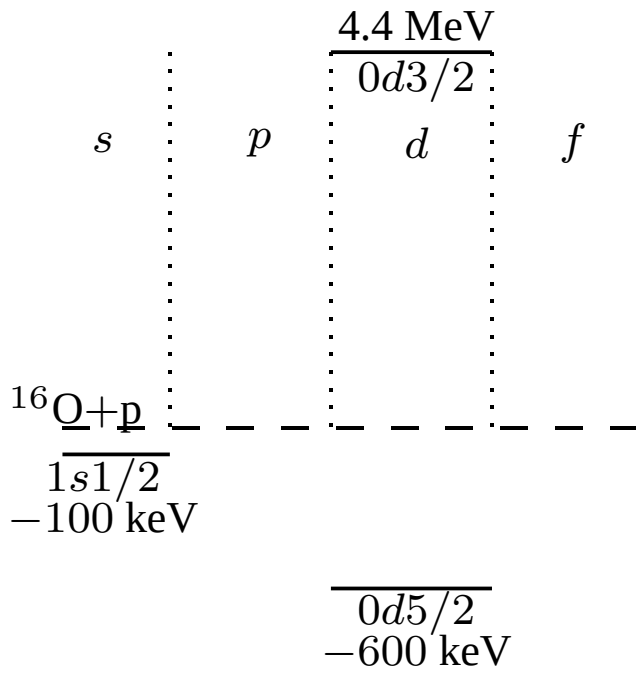
ΔE-E matrices



Finally a bit of theory…

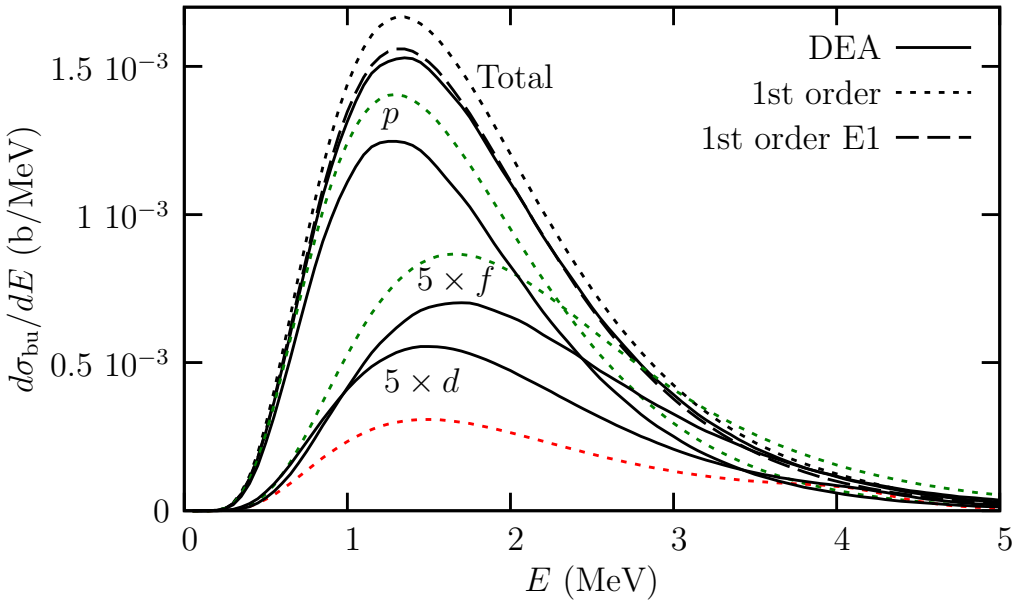
Meanwhile we have done ^{17}F breakup calculations

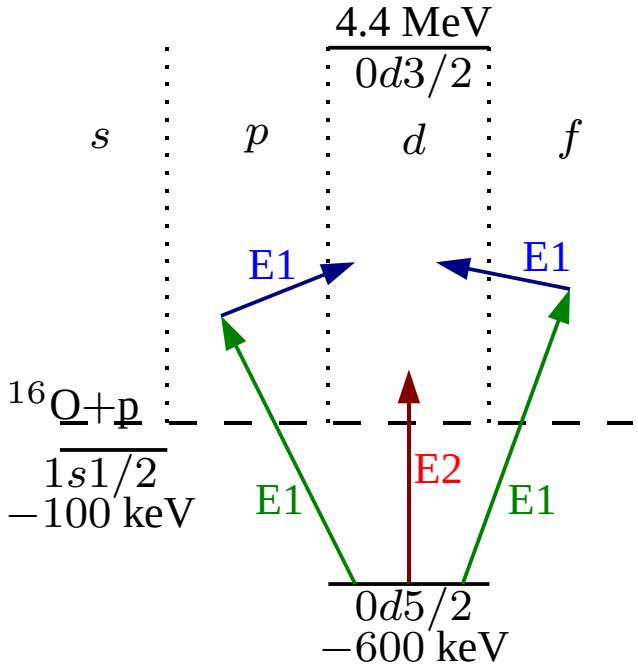
^{17}F modelled as $^{16}\mathrm{O}(0^+)$+p:



Coulomb breakup calculation

$^{17}\mathrm{F} + \mathrm{Pb} \rightarrow {}^{16}\mathrm{O} + \mathrm{p} + \mathrm{Pb}\ \ 40A\mathrm{MeV}$





- Dominated by E1 (populates p and f waves)
- But significant E2 (d wave)
  and higher orders (p and $f \rightarrow d$)

Summary

Coulomb breakup is proposed as a tool to infer radiative-capture cross section at low E

However never tested

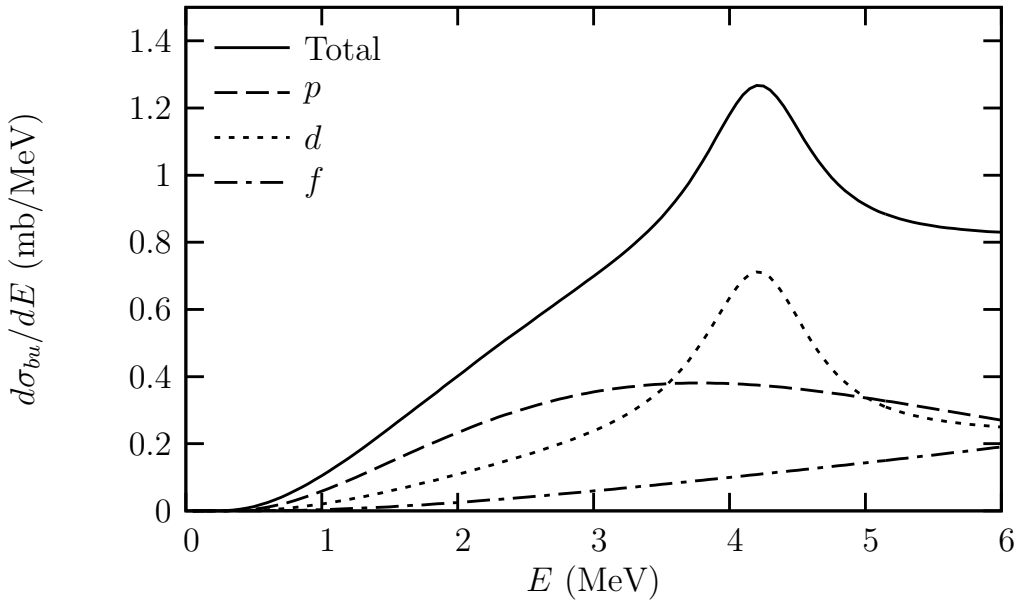
^{8}B study suggests hypotheses not satisfied

^{17}F is an ideal test case

$\Rightarrow$ Measure Coulomb breakup of ^{17}F on Pb to test the Coulomb-breakup method

Measure has been performed at LNS (Catania)
Analysis is planned for 2009-2010

Nuclear breakup calculation



- Nuclear breakup emphasizes resonant states
  $\Rightarrow$ can be used to test our ^{17}F model in continuum
- In addition to Coulomb breakup, we measure breakup on C target
- $d3/2$ resonance should be seen experimentally

^{17}F vs ^{8}B

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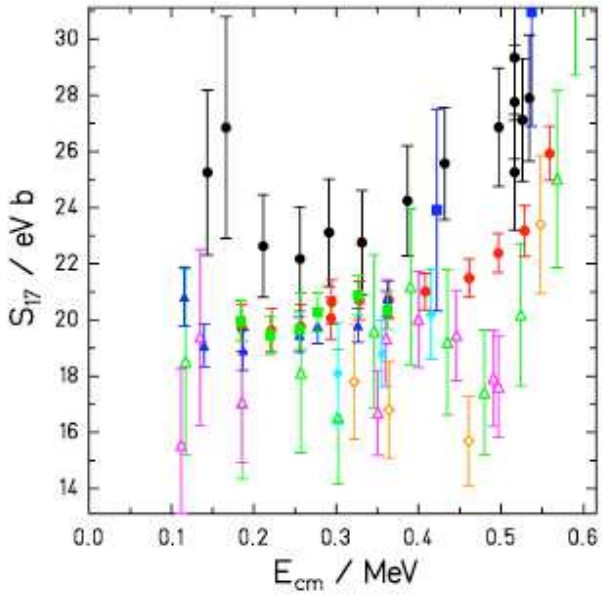

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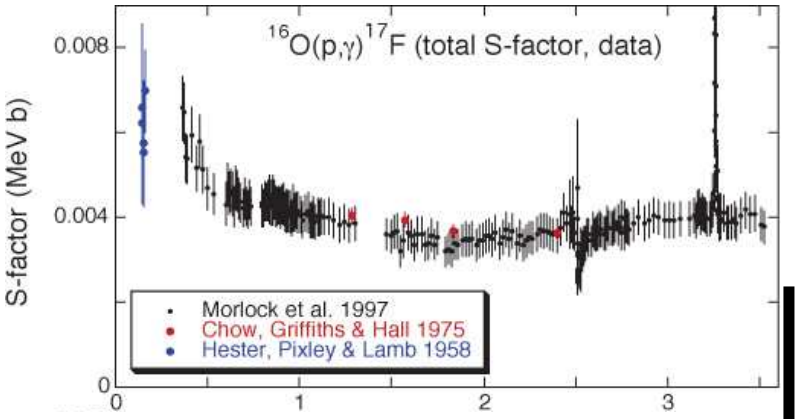
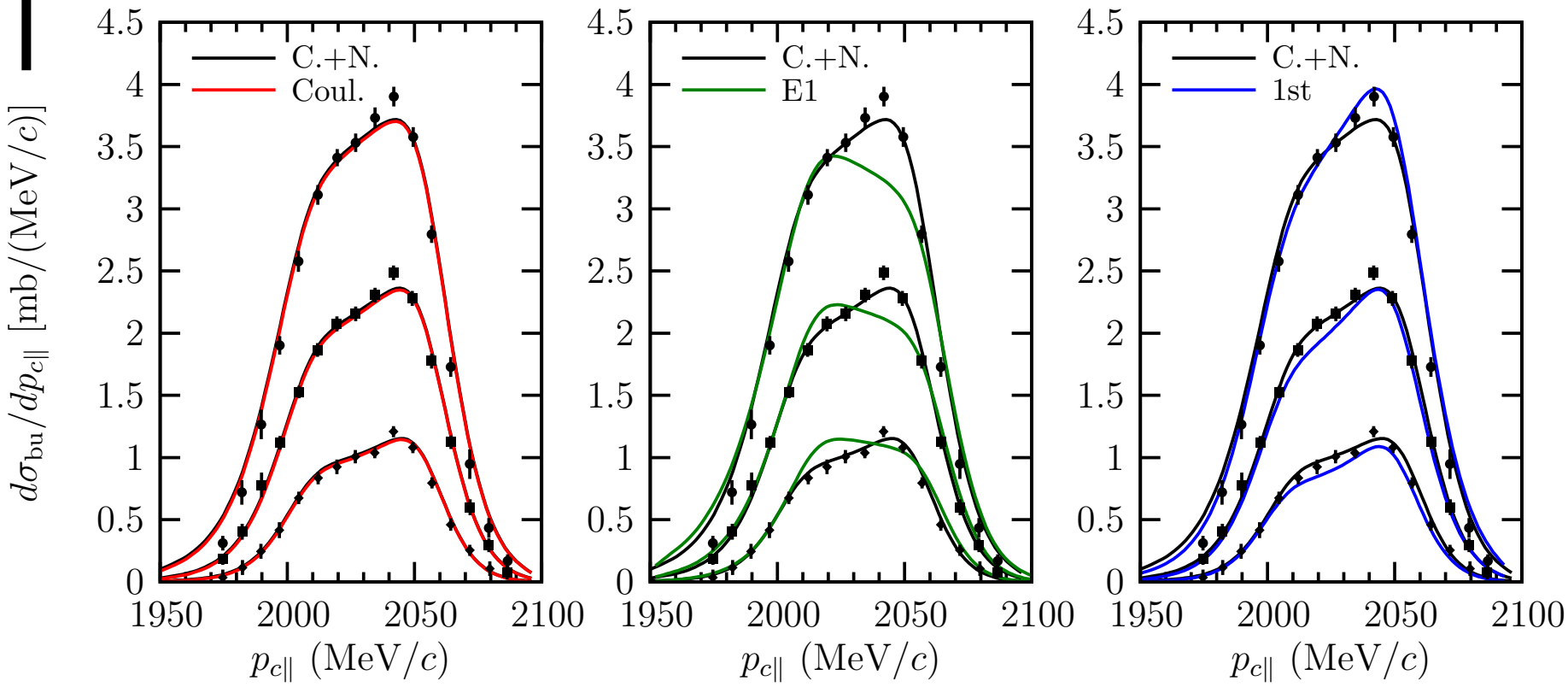


$\Rightarrow$ We propose to measure ^{17}F Coulomb breakup

Analysis of ^{8}B Coulomb breakup

^{8}B + Pb @ 44 AMeV (MSU) [Davids PRL 81, 2209 (01)]



Nuclear interaction negligible at forward angles

Significant E1-E2 interference (asymmetry)

First-order: too asymmetric $\Rightarrow$ higher-order